Dynamic properties of the cell in disease: Modeling the Impact of Microgravity at the Cellular Level

Propiedades dinámicas de la célula en la enfermedad: modelado del impacto de la microgravedad a nivel celular.

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Introduction: When subjected to microgravity in space, the equilibrium between cell architecture and the external force is disturbed, resulting in changes at the cellular and sub-cellular levels (e.g., cytoskeleton, signal transduction, membrane permeability, etc.).

Multicellular organisms shape development and remove aberrant cells by programmed cell death (”apoptosis”). Because defective cell death (too little or too much) is implicated in various diseases (like cancer and autoimmunity), understanding how apoptosis is regulated is an important goal of molecular cell biologists. Cell apoptosis keeps the secret of alterations in microgravity.

This comprehensive review indicates the potential of the space environment in biomedical research.

Objective: This research seeks to hypothesize how micro gravity changes cells, allowing them to be more vulnerable to loss of bio stability.

Research Highlights: Review of current mathematical modelling approaches in literature. Workflow for model development. Overview over current modelling techniques and their mathematical frameworks. Modeling the Impact of Microgravity at the Cellular Level. Discussions of the benefits of modelling and outlook. After creating the basic models of the apoptosis pathways, currently systems biology of cell death is entering a next very important phase. A very ambitious question to address is what the role of the apoptotic network is in the diseases of the century e.g. ageing and metabolic diseases.

Analyze the differential equations with standard tools of dynamical systems theory (phase-plane analysis and bifurcation theory), and we simulate their solutions numerically with standard algorithms for stiff ordinary differential equations (ODEs).

Exposure to microgravity has been associated with various significant changes in the organization and function of several tissues. Generally, exposure to simulated microgravity enhances apoptosis, although the cell death rate greatly varies depending on cell types, times of exposition, and culture conditions. The central question now is how defects in apoptotic networks are connected to various diseases and how apoptosis models could be used to develop better treatments.

Conclusion: Simulated microgravity conditions can lead the alterations of apoptosis. It was confirmed that simulated microgravity (SMG) led to ultrastructural alterations and apoptosis in many types of cells. Simulated microgravity through rotary cell culture system had significant effects on human cells: the cell cycle and ultrastructure were impaired, apoptosis increased, migration ability decreased, and the expression of BCL-2, cyclin D3, and MMP9 were affected.

Programmed cell death (apoptosis) has three defining dynamical features: a signal threshold that must be exceeded to elicit cell death, a long- and variable-time delay between the signal and the response, and irreversible commitment to cellular disassembly once the terminal proteases have been activated. From the available experimental data, we have identified those molecular interactions that, we believe, are key components of the mechanisms ensuring these properties of programmed cell death.

The hypothesis from mechanisms and theoretical mathematical models describes: The most representative micro-gravity alteration is developed from understanding that when there is greater cellular stress; greater is the delay of apoptosis, generating hyperactivity of apoptosis; loss of cell balance, degenerating tissues faster.

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